Palaeontological Impact Assessment for the proposed Soyuz 2 Solar PV Park, south of Britstown, Northern Cape Province

Desktop Study (Phase 1)

For

ACO Associates (Pty) Ltd

17 June 2023

Prof Marion Bamford
Palaeobotanist
P Bag 652, WITS 2050
Johannesburg, South Africa
Marion.bamford@wits.ac.za

Expertise of Specialist

The Palaeontologist Consultant: Prof Marion Bamford
Qualifications: PhD (Wits Univ, 1990); FRSSAf, mASSAf
Experience: 34 years research and lecturing in Palaeontology
26 years PIA studies and over 350 projects completed

Declaration of Independence

This report has been compiled by Professor Marion Bamford, of the University of the Witwatersrand, sub-contracted by ACO Associates (Pty) Ltd, Cape Town, South Africa. The views expressed in this report are entirely those of the author and no other interest was displayed during the decision making process for the Project.

Specialist: Prof Marion Bamford

Signature:

Executive Summary

A Palaeontological Impact Assessment was requested for the proposed development of the Soyuz 2 Solar PV Park, south of Britstown, Northern Cape Province. This park is one of six proposed facilities and will be located on Portion 2 of Farm 97 and is expected to generate 300 MW of energy for the Soyuz 2(1) park and 300 MW for the Soyuz 2(2) park.

To comply with the regulations of the South African Heritage Resources Agency (SAHRA) in terms of Section 38(8) of the National Heritage Resources Act, 1999 (Act No. 25 of 1999) (NHRA), a desktop Palaeontological Impact Assessment (PIA) was completed for the proposed development.

The proposed site lies on the moderately fossiliferous Quaternary sands and alluvium and on the non-fossiliferous Jurassic dolerite. No pans are evident in this area from the satellite imagery. Nonetheless, a Fossil Chance Find Protocol should be added to the EMPr. Based on this information it is recommended that no further palaeontological impact assessment is required unless fossils are found by the contractor, environmental officer or other designated responsible person once excavations or drilling for foundations, infrastructure and amenities have commenced. **The impact will be low (both pre- and post-mitigation). There will be no cumulative impact and there are no no-go areas.**

Table of Contents

1. Background

The proposal to construct solar Energy facilities (SEFs) to the south of Britstown, Northern Cape Province, requires an Environmental Impact assessment for each of the solar parks, the Soyuz 1-6 Solar PV Parks. This report is for palaeontological impact for the Soyuz 1 Solar PV Park that will be located on Portion 3 of Farm 145 (Figures 1-2).

Table 1: Project Information

Project Related Info	SOYUZ 2 SOLAR PV PARK
Project Description	Soyuz 2 Solar PV Park (Pty) Ltd proposes the development of the Soyuz 2 Solar PV Park and associated infrastructure ("the Project"), near Britstown, Northern Cape Province. The Project will be located on Portion 2 of Farm 97. The project will have a generating capacity of no more than 300MW and Battery Energy Storage Systems ("BESS") of 1200MWh. Bi-facial, single axis trackers will be utilised for the panels. An on-site substation with a capacity of 300MVA, will enable the connection of a 132kV Overhead Powerline ("OHPL"). The final interconnection solution will be dependent on the requirements of Eskom, which are still to be defined. Terramanzi Group (Pty) Ltd have been appointed to facilitate the Scoping & EIA process to obtain environmental authorisation in terms of the National Environmental Management Act ("NEMA") Environmental Impact Assessment ("EIA") Regulations (2014), as amended. The purpose of the facility is to generate clean electricity from a renewable energy source (i.e., solar radiation) in order to contribute to the National energy grid and/or any Private off takers (where applicable).
Contracted Capacity of PVSEF	300MW
Need and Desirability of the Proposed activity, including the need and desirability of the activity in the context of the preferred location (motivation of the preferred site)	Suitable open land/space for solar facility development with a sufficiently high solar resource Renewable energy generation to add capacity to national grid Contributes to energy mix Employment opportunities Skills development No exceedence of environmental sensitivities
What other infrastructure does the client want to include in this Process (PVSEF, WEF, BESS, Substation, switching station, access roads etc.)	PV Solar Energy Facility including bifacial PV modules, single axis trackers, inverters and transformers, and underground and overhead cabling up to 33kV between project components
	1,500 m^2 O&M building
	3,000 m^2 Paved areas
	60,000 m^2 Battery Energy Storage System (1200 MWh)
	15,000 m^2 back to back substation (including facility substation, and Eskom collector/switching station with feeder bays) (300MW)

	Access and internal roads
	Fencing around development area
	10,000 m^2 Temporary construction camp
	40,000 m^2 Temporary laydown areas
Does the project form part of a Renewable Energy Development Zone (REDZ) as per GN 114? Does the project form part of an Electricity Grid Infrastructure (EGI) as per GN 113 (Strategic Transmission Corridor - STC) ?	Not in REDZ - EAP to also confirm. EGI not applicable now as no OHPL determined yet.
Technical Specifications (Type of Technology used, I.e Fixed tilt, single axis, height of the solar panels etc.)	Bifacial solar PV modules installed on single axis tracker mounting structure at a height of up to 6m above ground level
Lifespan of the project (ex. 30 Years)	30 years
How many new employment opportunities will be created in the development and construction phase of the activity/ies?	Approx 150 during construction Approx 40-50 during operations
Will the labourers be sourced locally / Provincially	Both locally and provincially
Is there a previous EA done for this site/ project	No

A Palaeontological Impact Assessment was requested for the Soyuz 2 Solar PV Park project. To comply with the regulations of the South African Heritage Resources Agency (SAHRA) in terms of Section 38(8) of the National Heritage Resources Act, 1999 (Act No. 25 of 1999) (NHRA), a desktop Palaeontological Impact Assessment (PIA) was completed for the proposed development and is reported herein.

Table 1: National Environmental Management Act, 1998 (Act No. 107 of 1998) (NEMA) and Environmental Impact Assessment (EIA) Regulations, 2014 (as amended) - Requirements for Specialist Reports (Appendix 6).

	A specialist report prepared in terms of the Environmental Impact Regulations of 2017 must contain:	Relevant section in report
ai	Details of the specialist who prepared the report,	Appendix B
aii	The expertise of that person to compile a specialist report including a curriculum vitae	Appendix B
b	A declaration that the person is independent in a form as may be specified by the competent authority	Page 1
c	An indication of the scope of, and the purpose for which, the report was prepared	Section 1
ci	An indication of the quality and age of the base data used for the specialist report: SAHRIS palaeosensitivity map accessed – date of this report	Yes
cii	A description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change	Section 5
d	The date and season of the site investigation and the relevance of the season to the outcome of the assessment	N/A
e	A description of the methodology adopted in preparing the report or carrying out the specialised process	Section 2
f	The specific identified sensitivity of the site related to the activity and its associated structures and infrastructure	Section 4
g	An identification of any areas to be avoided, including buffers	N/A
h	A map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;	N/A
i	A description of any assumptions made and any uncertainties or gaps in knowledge;	Section 5
j	A description of the findings and potential implications of such findings on the impact of the proposed activity, including identified alternatives, on the environment	Section 4
k	Any mitigation measures for inclusion in the EMPr	Section 8, Appendix A
l	Any conditions for inclusion in the environmental authorisation	N/A
m	Any monitoring requirements for inclusion in the EMPr or environmental authorisation	Section 8, Appendix A
ni	A reasoned opinion as to whether the proposed activity or portions thereof should be authorised	Section 6
nii	If the opinion is that the proposed activity or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan	Sections 6, 8
o	A description of any consultation process that was undertaken during the course of carrying out the study	N/A

	A specialist report prepared in terms of the Environmental Impact Regulations of 2017 must contain:	Relevant section in report
p	A summary and copies of any comments that were received during any consultation process	N/A
q	Any other information requested by the competent authority.	N/A
2	Where a government notice gazetted by the Minister provides for any protocol or minimum information requirement to be applied to a specialist report, the requirements as indicated in such notice will apply.	N/A

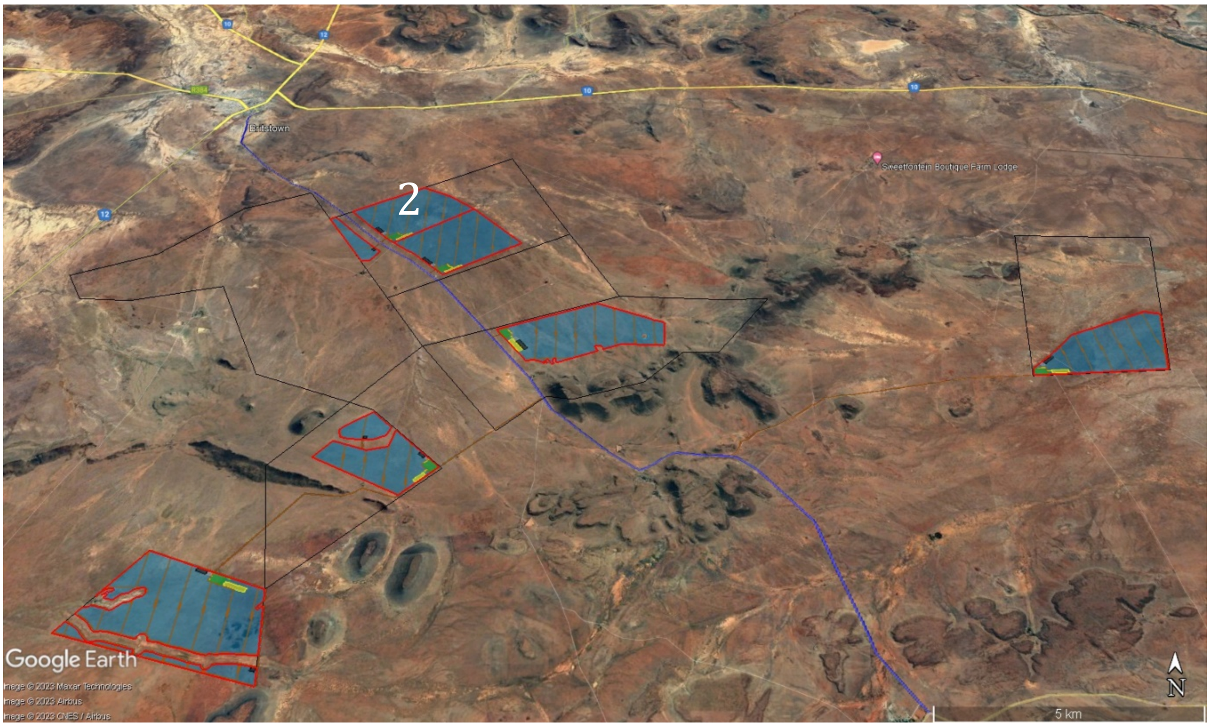

Figure 1: Google Earth map of the general area to show the relative positions of the Soyuz Solar PV Parks. The Soyuz 2 facility is shown by the number.

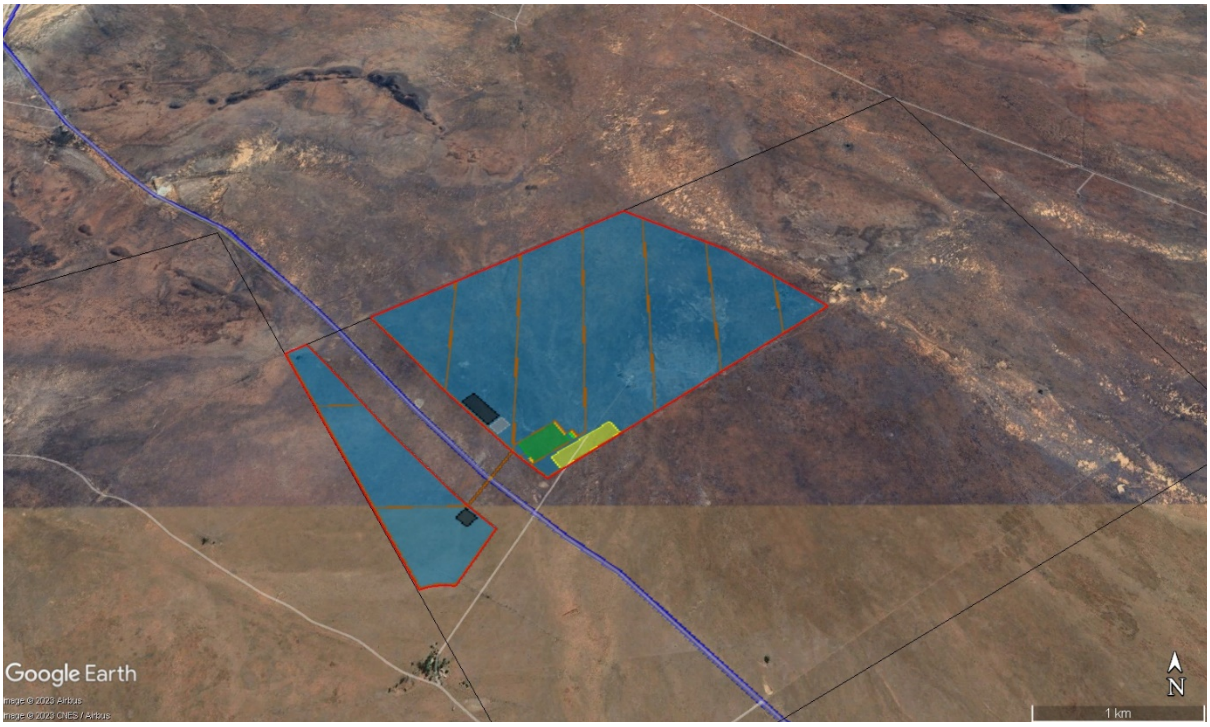

Figure 2: Google Earth Map of the proposed location of the Soyuz 2 Solar PV Park shown by the white polygons. Soyuz 2(1) is in the northeast and Soyuz 2(2) is to the southwest. Map supplied by Terramanzi (Pty) Ltd.

2. Methods and Terms of Reference

The Terms of Reference (ToR) for this study were to undertake a PIA and provide feasible management measures to comply with the requirements of SAHRA.

The methods employed to address the ToR included:

1. Consultation of geological maps, literature, palaeontological databases, published and unpublished records to determine the likelihood of fossils occurring in the affected areas. Sources included records housed at the Evolutionary Studies Institute at the University of the Witwatersrand and SAHRA databases;
2. Where necessary, site visits by a qualified palaeontologist to locate any fossils and assess their importance (*not applicable to this assessment*);
3. Where appropriate, collection of unique or rare fossils with the necessary permits for storage and curation at an appropriate facility (*not applicable to this assessment*); and
4. Determination of fossils' representivity or scientific importance to decide if the fossils can be destroyed or a representative sample collected (*not applicable to this assessment*).

3. Geology and Palaeontology

i. Project location and geological context

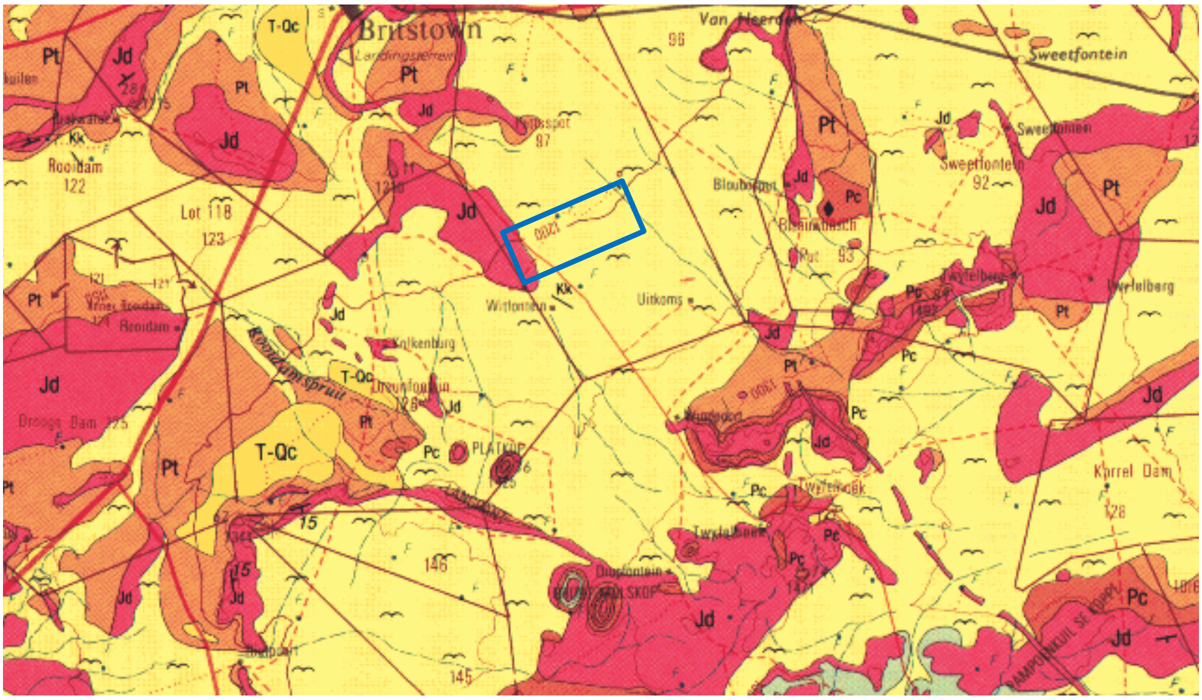

Figure 3: Geological map of the area around the Soyuz 2 Solar PV Park. The location of the proposed project is indicated within the blue rectangle. Abbreviations of the rock types are explained in Table 2. Map enlarged from the Geological Survey 1: 250 000 map 3022 Britstown.

Table 2: Explanation of symbols for the geological map and approximate ages (Eriksson et al., 2006. Johnson et al., 2006; Partridge et al., 2006). SG = Supergroup; Fm = Formation; Ma = million years; grey shading = formations impacted by the project.

Symbol	Group/Formation	Lithology	Approximate Age
Q	Quaternary	Alluvium, sand, calcrete	Quaternary Ca 1.0 Ma to present
T-Qc	Tertiary calcrete	Sand, calcrete	Tertiary
Jd	Jurassic dykes	Dolerite dykes, intrusive	Jurassic, approx. 183 Ma
Pa	Koonap Fm, Adelaide Subgroup, Beaufort Group, Karoo SG	Mudstone, sandstone	Late Permian, ca 266 - 260 Ma
Pc/Pwa	(Carnarvon) Waterford Fm, Ecca Group, Karoo SG	Sandstone, shale	Middle Permian ca 269 – 266 Ma
Pt	Tierberg/Fort Brown Fm, Ecca Group, Karoo SG	Brown to grey shale	Middle Permian ca 269 – 266 Ma

The project lies in the northwestern part of the main Karoo Basin where the Ecca and lower Beaufort Group rocks are exposed. Much of the area is covered by Quaternary sands and alluvium (Figure 3).

The Karoo Supergroup rocks cover a very large proportion of South Africa and extend from the northeast (east of Pretoria) to the southwest and across to almost the KwaZulu Natal south coast. It is bounded along the southern margin by the Cape Fold Belt and along the northern margin by the much older Transvaal Supergroup rocks. Representing some 120 million years (300 – 183Ma), the Karoo Supergroup rocks have preserved a diversity of fossil plants, insects, vertebrates and invertebrates.

During the Carboniferous Period South Africa was part of the huge continental landmass known as Gondwanaland and it was positioned over the South Pole. As a result, there were several ice sheets that formed and melted, and covered most of South Africa (Visser, 1986, 1989; Isbell et al., 2012). Gradual melting of the ice as the continental mass moved northwards and the earth warmed, formed fine-grained sediments in the large inland sea. These are the oldest rocks in the system and are exposed around the outer part of the ancient Karoo Basin, and are known as the Dwyka Group (Johnson et al., 2006).

Overlying the Dwyka Group rocks are rocks of the Ecca Group that are Early Permian in age. There are eleven formations recognised in this group but they do not all extend throughout the Karoo Basin. In the west and central part are the following formations, from base upwards: Prince Albert Formation, Whitehill Formation, Collingham Formation, Laingsburg / Ripon Formations, **Tierberg** / Fort Brown Formations, and **Waterford Formation**. The Carnarvon Formation is an old term and the current accepted term is the Waterford Formation (Groenewald et al., 2022). All of these sediments have varying proportions of sandstones, mudstones, shales and siltstones and represent shallow to deep water settings, deltas, rivers, streams and overbank depositional environments.

Overlying the Ecca Group are the rocks of the Beaufort Group that has been divided into the lower **Adelaide Subgroup** for the Upper Permian strata, and the Tarkastad Subgroup for the Early to Middle Triassic strata. As with the older Karoo sediments, the formations vary across the Karoo Basin.

In this part of the basin, east of 24°E, three formations are recognised in the Adelaide Subgroup, the basal Koonap Formation, the Middleton Formation and the thick Balfour Formation (Rubidge, 2005; Smith et al., 2020). From the recent map provided in Smith et al. (2020), it is likely that the Koonap Formation is present in this area.

Large exposures of Jurassic dolerite dykes occur throughout the area. These intruded through the Karoo sediments around 183 million years ago at about the same time as the Drakensberg basaltic eruption. These volcanic rocks do not preserve fossils.

There are numerous pans in the Kalahari, generally 3–4 km in diameter (Haddon and McCarthy, 2005). According to Goudie and Wells (1995) there are two conditions required for the formation of pans. Firstly, the fluvial processes must not be integrated, and second, there must be no accumulation of aeolian material that would fill the irregularities or depressions in the land surface. Favoured materials or substrates for the formation of pans in South Africa are Dwyka and Ecca shales and sandstones (ibid).

ii. Palaeontological context

The palaeontological sensitivity of the area under consideration is presented in Figure 4. The site for development is in the Quaternary sands and alluvium for Soyuz 2(1) and mostly on non-fossiliferous Jurassic dolerite for Soyuz 2(2).

Jurassic dolerite is an intrusive volcanic rock and does not preserve any fossils. Where dolerites have intruded through the Karoo Supergroup they tend to destroy any fossils in their immediate vicinity because the dolerite is hot and molten when it intrudes, then it cools and solidifies.

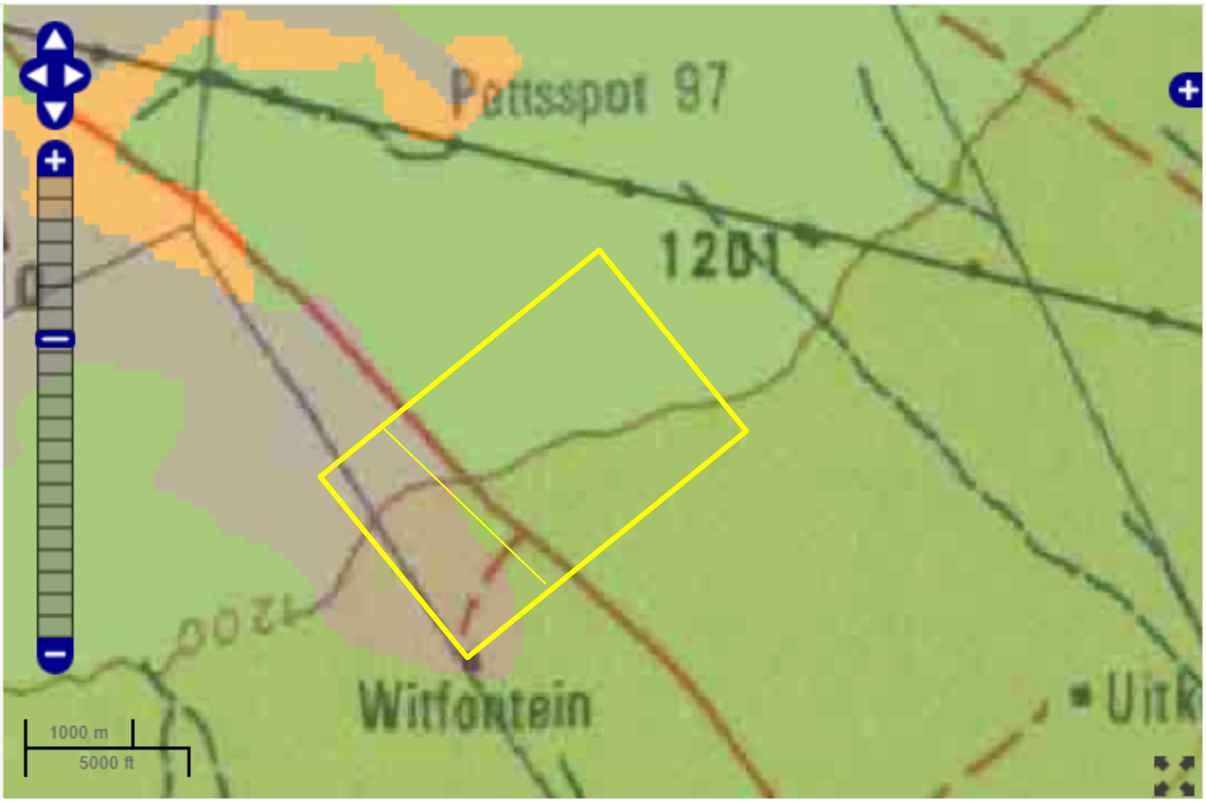

Figure 4: SAHRIS palaeosensitivity map for the site for the proposed Soyuz 2 Solar PV Park shown within the yellow rectangle. Background colours indicate the following degrees of sensitivity: red = very highly sensitive; orange/yellow = high; green = moderate; blue = low; grey = insignificant/zero.

Sands of the Quaternary period do not preserve fossils but might obscure traps such as palaeo-pans, palaeo-springs or tufas. Most pans in the Kalahari Basin are filled by a layer of clayey sand or calcareous clays and are flanked by lunette dunes formed as a result of deflation of the pan floor during arid periods (Lancaster, 1978a,b; Haddon and McCarthy, 2005). At some localities in the south western Kalahari spring-fed tufas have formed at the margins of pans during periods where groundwater discharge was high (Lancaster, 1986). These tufas may contain evidence of algal mats and stromatolites and may also be associated with calcified reed and root tubes (Lancaster, 1986). Many of the pans are characterised by diatomaceous earth, diatomite or kieselguhr, a white or grey, porous, light-weight, fine-grained sediment composed mainly of the fossilised skeletons of diatoms. Associated with some palaeo-pans and palaeo-springs are fossil bones, root casts, pollen and archaeological artefacts.

From the SAHRIS map above the area is indicated as moderately sensitive (green) for the Quaternary sands and alluvium and with zero to insignificant sensitivity (grey) for the Jurassic dolerite.

4. Impact assessment

Table 3: Definitions of Terminology (Tables from Terramanzi (Pty) Ltd, 2021).

ITEM	DEFINITION
EXTENT	
Local	Extending only as far as the boundaries of the activity, limited to the site and its immediate surroundings
Regional	Impact on the broader region
National	Will have an impact on a national scale or across international borders
DURATION	
Short-term	0-5 years
Medium-Term	5-15 years
Long-Term	>15 years, where the impact will cease after the operational life of the activity
Permanent	Where mitigation, either by natural process or human intervention, will not occur in such a way or in such a time span that the impact can be considered transient.
MAGNITUDE OR INTENSITY	
Low	Where the receiving natural, cultural or social function/environment is negligibly affected or where the impact is so low that remedial action is not required.

Medium	Where the affected environment is altered, but not severely and the impact can be mitigated successfully and natural, cultural or social functions and processes can continue, albeit in a modified way.
High	Where natural, cultural or social functions or processes are substantially altered to a very large degree. If a negative impact then this could lead to unacceptable consequences for the cultural and/or social functions and/or irreplaceable loss of biodiversity to the extent that natural, cultural or social functions could temporarily or permanently cease.
PROBABILITY	
Improbable	Where the possibility of the impact materialising is very low, either because of design or historic experience
Probable	Where there is a distinct possibility that the impact will occur
Highly Probable	Where it is most likely that the impact will occur
Definite	Where the impact will undoubtedly occur, regardless of any prevention measures
SIGNIFICANCE	
Low	Where a potential impact will have a negligible effect on natural, cultural or social environments and the effect on the decision is negligible. This will not require special design considerations for the project
Medium	Where it would have, or there would be a moderate risk to natural, cultural or social environments and should influence the decision. The project will require modification or mitigation measures to be included in the design
High	Where it would have, or there would be a high risk of, a large effect on natural, cultural or social environments. These impacts should have a major influence on decision making.
Very High	Where it would have, or there would be a high risk of, an irreversible negative impact on biodiversity and irreplaceable loss of natural capital that could result in the project being environmentally unacceptable, even with mitigation. Alternatively, it could lead to a major positive effect. Impacts of this nature must be a central factor in decision making.
STATUS OF IMPACT	
Whether the impact is positive (a benefit), negative (a cost) or neutral (status quo maintained)	
DEGREE OF CONFIDENCE IN PREDICTIONS	

The degree of confidence in the predictions is based on the availability of information and specialist knowledge (e.g. low, medium or high)
MITIGATION
Mechanisms used to control, minimise and or eliminate negative impacts on the environment and to enhance project benefits Mitigation measures should be considered in terms of the following hierarchy: (1) avoidance, (2) minimisation, (3) restoration and (4) off-sets.

2. Scoring System for Impact Assessment Ratings

To comparatively rank the impacts, each impact has been assigned a score using the scoring system outlined in the Table below. This scoring system allows for a comparative, accountable assessment of the indicative cumulative positive or negative impacts of each aspect assessed.

IMPACT PARAMETER	SCORE
Extent (A)	**Rating**
Local	1
Regional	2
National	3
Duration (B)	**Rating**
Short term	1
Medium Term	2
Long Term	3
Permanent	4
Probability (C)	**Rating**
Improbable	1
Probable	2
Highly Probable	3

Definite	4	
IMPACT PARAMETER	**NEGATIVE IMPACT SCORE**	**POSITIVE IMPACT SCORE**
Magnitude/Intensity (D)	**Rating**	**Rating**
Low	-1	1
Medium	-2	2
High	-3	3
SIGNIFICANCE RATING (F) = (A*B*D)*C	**Rating**	**Rating**
Low	0 to - 40	0 to 40
Medium	- 41 to - 80	41 to 80
High	- 81 to - 120	81 to 120
Very High	> - 120	> 120

IMPACT NATURE	**Impact – Nature of Impact** **Palaeontological Impact – Loss of fossils**		**STATUS**	**POSITIVE/NEGATIVE**
Impact Description	Excavations for foundations and infrastructure might destroy any fossils that are present.			
Impact Source(s)	Excavations for foundations and infrastructure			
Receptor(s)	Fossils in the rocks			
PARAMETER	**WITHOUT MITIGATION**	**SCORE**	**WITH MITIGATION**	**SCORE**
EXTENT (A)	Preferred Alternative:	1	Preferred Alternative:	1
	No-Go Alternative:	n/a	No-Go Alternative:	n/a
DURATION (B)	Preferred Alternative:	4	Preferred Alternative:	4

	No-Go Alternative:	n/a	No-Go Alternative:	n/a
PROBABILITY (C)	Preferred Alternative:	1	Preferred Alternative:	1
	No-Go Alternative:	n/a	No-Go Alternative:	n/a
INTENSITY OR MAGNITUDE (D)	Preferred Alternative:	-2	Preferred Alternative:	2
	No-Go Alternative:	n/a	No-Go Alternative:	n/a
SIGNIFICANCE RATING (F) = (A*B*D)*C	Preferred Alternative:	**-8**	Preferred Alternative:	**8**
	No-Go Alternative:	**n/a**	No-Go Alternative:	**n/a**
CUMULATIVE IMPACTS	None. Each site is unique and may or may not have fossils. Fossils in one site will not affect fossils in another site			
CONFIDENCE	High			
MITIGATION MEASURES	Remove any fossils that are seen on the surface or discovered below ground when the excavations commence			

Phase
There would potentially be an impact only during the Construction Phase when the ground will be broken for foundations and amenities. Fossils are inert and inactive so do not move. There would be no impact during the operational and decommissioning phases.

Mitigation
The impact on the palaeontological heritage can be reduced greatly by the contractor or environmental officer looking for fossils when excavations commence and removing any scientifically important fossils with the relevant SAHRA permit.
(See Section 8 and Appendix A).

Positive/Negative Impact
The discovery and removal of fossils as a direct result of this project has a positive impact because prior to this project the particular fossils or fossil deposit were unknown to science.

Additional Environmental Impacts
As far as the palaeontology is concerned, there are no additional impacts because the fossils are inert and inactive.

Cumulative Impacts
As far as the palaeontology is concerned, there are no cumulative impacts because each site is unique and may or may not have fossils. Fossil bones may be scattered over the

landscape but their distribution is erratic and unpredictable. If a bone-bed or plant outcrop occurs this would be in an aerially small concentration of fossils and very unlikely to extend beyond tens of metres. Therefore, projects on adjacent land parcels are unlikely to add any impact on this project.

No-Go areas
There are no-go areas because the fossils, if present, can be removed and curated in a recognised institution such as a museum or university that has the facilities to store and research the fossil material.

Alternative sites
As far as the palaeontology is concerned, all six sites have the same significance so there is no preference.

Based on the nature of the project, surface activities may impact upon the fossil heritage if preserved in the development footprint. The geological structures suggest that the rocks are the wrong type to preserve fossils being dolerite or loose sand. Since the sand might obscure fossil traps such as palaeo-pans or palaeo-springs and may be disturbed a Fossil Chance Find Protocol has been added to this report. Taking account of the defined criteria, the potential impact to fossil heritage resources is extremely low.

5. Assumptions and uncertainties

Based on the geology of the area and the palaeontological record as we know it, it can be assumed that the formation and layout of the dolomites, sandstones, shales and sands are typical for the country and only some contain trace fossils, fossil plant, insect, invertebrate and vertebrate material. The sands of the Quaternary period would not preserve fossils but might cover fossil traps such as palaeo-pans or palaeo-springs.

6. Recommendation

Based on experience and the lack of any previously recorded fossils from the area, it is extremely unlikely that any fossils would be preserved in the overlying sands and alluvium of the Quaternary because there are no fossil traps such as palaeo-pans or palaeo-springs evident in the satellite imagery. There is a very small chance that the sands might obscure such fossils traps so a Fossil Chance Find Protocol should be added to the EMPr. The dolerite would not preserve any fossils. If fossils are found by the environmental officer, or other responsible person once excavations for foundations, amenities and infrastructure have commenced then they should be rescued and a palaeontologist called to assess and collect a representative sample. The impact on the palaeontological heritage would be low pre- and post-mitigation. There is no no-go area and there is no cumulative impact.

7. References

Anderson, J.M., Anderson, H.M., 1985. Palaeoflora of Southern Africa: Prodromus of South African megafloras, Devonian to Lower Cretaceous. A.A. Balkema, Rotterdam. 423 pp.

Goudie, A.S., Wells, G.L., 1995. The nature, distribution and formation of pans in arid zones. Earth Science Reviews 38, 1–69.

Groenewald, D.P., Day, M.O., Penn-Clarke, C.R., Rubidge, B.S., 2022. Stepping out across the Karoo retro-foreland basin: Improved constraints on the Ecca-Beaufort shoreline along the northern margin. Journal of African Earth Sciences 185 (2022) 104389.

Haddon. I.G., McCarthy, T.S., 2005. The Mesozoic–Cenozoic interior sag basins of Central Africa: The Late-Cretaceous–Cenozoic Kalahari and Okavango basins. Journal of African Earth Sciences 43, 316–333.

Isbell, J.L., Henry, L.C., Gulbranson, E.L., Limarino, C.O., Fraiser, F.L., Koch, Z.J., Ciccioli, P.l., Dineen, A.A., 2012. Glacial paradoxes during the late Paleozoic ice age: Evaluating the equilibrium line altitude as a control on glaciation. Gondwana Research 22, 1-19.

Johnson, M.R., van Vuuren, C.J., Visser, J.N.J., Cole, D.I., Wickens, H.deV., Christie, A.D.M., Roberts, D.L., Brandl, G., 2006. Sedimentary rocks of the Karoo Supergroup. In: Johnson, M.R., Anhaeusser, C.R. and Thomas, R.J., (Eds). The Geology of South Africa. Geological Society of South Africa, Johannesburg / Council for Geoscience, Pretoria. Pp 461 – 499.

Lancaster, I.N., 1978a. The pans of the southern Kalahari, Botswana. Geographical Journal 144, 80–98.

Lancaster, I.N., 1978b. Composition and formation of southern Kalahari pan margin dunes. Zeitschrift fu¨ r Geomorphologie 22, 148–169.

Lancaster, N., 1986. Pans in the southwestern Kalahari: a preliminary report. Palaeoecology of Africa 17, 59–67.

Plumstead, E.P., 1969. Three thousand million years of plant life in Africa. Geological Society of southern Africa, Annexure to Volume LXXII. 72pp + 25 plates.

Smith, R.M.H., Rubidge, B.S., Day, M.O., Botha, J., 2020. Introduction to the tetrapod biozonation of the Karoo Supergroup. South African Journal of Geology 123(2), 131-140.

Visser, J.N.J., 1986. Lateral lithofacies relationships in the glacigene Dwyka Formation in the western and central parts of the Karoo Basin. Transactions of the Geological Society of South Africa 89, 373-383.

Visser, J.N.J., 1989. The Permo-Carboniferous Dwyka Formation of southern Africa: deposition by a predominantly subpolar marine icesheet. Palaeogeography, Palaeoclimatology, Palaeoecology 70, 377-391.

8. Chance Find Protocol

Monitoring Programme for Palaeontology – to commence once the excavations / drilling activities begin.

1. The following procedure is only required if fossils are seen on the surface and when drilling/excavations commence.
2. When excavations begin the rocks and discard must be given a cursory inspection by the environmental officer or designated person. Any fossiliferous material (traces, plants, insects, bone or coal) should be put aside in a suitably protected place. This way the project activities will not be interrupted.
3. Photographs of similar fossils must be provided to the developer to assist in recognizing the fossil plants, vertebrates, invertebrates or trace fossils in the shales and mudstones (for example see Figures 5-6). This information will be built into the EMP's training and awareness plan and procedures.
4. Photographs of the putative fossils can be sent to the palaeontologist for a preliminary assessment.
5. If there is any possible fossil material found by the contractor, developer or environmental officer then the qualified palaeontologist sub-contracted for this project, should visit the site to inspect the selected material and check the dumps where feasible.
6. Trace fossils, fossil plants or vertebrates that are considered to be of good quality or scientific interest by the palaeontologist must be removed, catalogued and housed in a suitable institution where they can be made available for further study. Before the fossils are removed from the site a SAHRA permit must be obtained. Annual reports must be submitted to SAHRA as required by the relevant permits.
7. If no good fossil material is recovered then no site inspections by the palaeontologist will be necessary. A final report by the palaeontologist must be sent to SAHRA once the project has been completed and only if there are fossils.
8. If no fossils are found and the excavations have finished then no further monitoring is required.

9. Appendix A – Examples of fossils from Quaternary alluvium

Figure 5: Photographs of transported and fragmentary fossils that could be found in the Quaternary sands and alluvium, or associated with pans.

10. Appendix B – Details of specialist

Curriculum vitae (short) - Marion Bamford PhD
January 2023

Present employment	:	Professor; Director of the Evolutionary Studies Institute. Member Management Committee of the NRF/DSI Centre of Excellence Palaeosciences, University of the Witwatersrand, Johannesburg, South Africa
Telephone	:	+27 11 717 6690
Cell	:	082 555 6937

E-mail : marion.bamford@wits.ac.za ; marionbamford12@gmail.com

ii) **Academic qualifications**
Tertiary Education: All at the University of the Witwatersrand:
1980-1982: BSc, majors in Botany and Microbiology. Graduated April 1983.
1983: BSc Honours, Botany and Palaeobotany. Graduated April 1984.
1984-1986: MSc in Palaeobotany. Graduated with Distinction, November 1986.
1986-1989: PhD in Palaeobotany. Graduated in June 1990.

iii) **Professional qualifications**
Wood Anatomy Training (overseas as nothing was available in South Africa):
1994 - Service d'Anatomie des Bois, Musée Royal de l'Afrique Centrale, Tervuren, Belgium, by Roger Dechamps
1997 - Université Pierre et Marie Curie, Paris, France, by Dr Jean-Claude Koeniguer
1997 - Université Claude Bernard, Lyon, France by Prof Georges Barale, Dr Jean-Pierre Gros, and Dr Marc Philippe

iv) **Membership of professional bodies/associations**
Palaeontological Society of Southern Africa
Royal Society of Southern Africa - Fellow: 2006 onwards
Academy of Sciences of South Africa - Member: Oct 2014 onwards
International Association of Wood Anatomists - First enrolled: January 1991
International Organization of Palaeobotany – 1993+
Botanical Society of South Africa
South African Committee on Stratigraphy – Biostratigraphy - 1997 - 2016
SASQUA (South African Society for Quaternary Research) – 1997+
PAGES - 2008 –onwards: South African representative
ROCEEH / WAVE – 2008+
INQUA – PALCOMM – 2011+onwards

v) **Supervision of Higher Degrees**

All at Wits University

Degree	Graduated/completed	Current
Honours	13	0
Masters	13	3
PhD	13	7
Postdoctoral fellows	14	4

vi) **Undergraduate teaching**
Geology II – Palaeobotany GEOL2008 – average 65 students per year
Biology III – Palaeobotany APES3029 – average 25 students per year
Honours – Evolution of Terrestrial Ecosystems; African Plio-Pleistocene Palaeoecology; Micropalaeontology – average 12 - 20 students per year.

vii) **Editing and reviewing**
Editor: Palaeontologia africana: 2003 to 2013; 2014 – Assistant editor

Guest Editor: Quaternary International: 2005 volume
Member of Board of Review: Review of Palaeobotany and Palynology: 2010 –
Associate Editor: Cretaceous Research: 2018-2020
Associate Editor: Royal Society Open: 2021 -
Review of manuscripts for ISI-listed journals: 30 local and international journals

viii) **Palaeontological Impact Assessments**
25 years' experience in PIA site and desktop projects

- Selected from recent projects only – list not complete:
- Skeerpoort Farm Mast 2020 for HCAC
- Vulindlela Eco village 2020 for 1World
- KwaZamakhule Township 2020 for Kudzala
- Sunset Copper 2020 for Digby Wells
- McCarthy-Salene 2020 for Prescali
- VLNR Lodge 2020 for HCAC
- Madadeni mixed use 2020 for Enviropro
- Frankfort-Windfield Eskom Powerline 2020 for 1World
- Beaufort West PV Facility 2021 for ACO Associates
- Copper Sunset MR 2021 for Digby Wells
- Sannaspos PV facility 2021 for CTS Heritage
- Smithfield-Rouxville-Zastron PL 2021 for TheroServe
- Glosam Mine 2022 for AHSA
- Wolf-Skilpad-Grassridge OHPL 2022 for Zutari
- Iziduli and Msenge WEFs 2022 for CTS Heritage
- Hendrina North and South WEFs & SEFs 2022 for Cabanga
- Dealesville-Springhaas SEFs 2022 for GIBB Environmental
- Vhuvhili and Mukondelei SEFs 2022 for CSIR
- Chemwes & Stilfontein SEFs 2022 for CTS Heritage
- Equestria Exts housing 2022 for Beyond Heritage
- Zeerust Salene boreholes 2022 for Prescali
- Tsakane Sewer upgrade 2022 for Tsimba
- Transnet MPP inland and coastal 2022 for ENVASS
- Ruighoek PRA 2022 for SLR Consulting (Africa)
- Namli MRA Steinkopf 2022 for Beyond Heritage

ix) **Research Output**
Publications by M K Bamford up to January 2022 peer-reviewed journals or scholarly books: over 170 articles published; 5 submitted/in press; 14 book chapters.
Scopus h-index = 31; Google Scholar h-index = 39; -i10-index = 116 based on 6568 citations.
Conferences: numerous presentations at local and international conferences.